Arch Orthop Trauma Surg (2016) 136:747–750
DOI 10.1007/s00402-016-2447-3

ORTHOPAEDIC SURGERY

Prevention of cement leakage into the hip joint by a standard cement plug during PFN-A cement augmentation: a technical note

M. Hanke[1] · V. Djonov[2] · M. Tannast[1] · M. J. Keel[1] · J. D. Bastian[1]

Received: 19 February 2016 / Published online: 24 March 2016

Abstract Medial penetration of the helical blade into the hip joint after fixation of trochanteric fractures using the proximal femur nail antirotation (PFN-A) is a potential failure mode. In low demand patients a blade exchange with cement augmentation may be an option if conversion to total hip arthroplasty is unfeasible to salvage the cut-through. This article describes a technique to avoid intraarticular cement leakage using a cement plug to close the defect in the femoral head caused by the cut-through.

Keywords Proximal femur fracture · Intramedullary nail · Cement augmentation · Cut-through · Salvage · Low demand

Introduction

In the management of peritrochanteric fractures the proximal femur nail antirotation (PFN-A) device, utilizing a helical blade, is a successful treatment option even in elderly patients with osteoporotic bone [1–4]. However, a "cut-through" of the helical blade—defined as a medial perforation of the blade through the cortex of the femoral head, without loss of reduction of the head–neck fragment [5, 6]—is noted in up to 6 % of cases [4, 5, 7, 8] (e.g., Fig. 1).

In general, blade telescoping using a trochanteric nail was higher in unstable fracture patterns compared to stable ones [9]. However, the risk for a cut-through may be higher using the PFN-A due to the helical design of the blade which potentially decreases the resistance to axial migration [10]. To decrease the risk for a cut-through, a tip–apex distance (TAD) of <20 mm should be avoided [7, 11]; and prereaming of the blade 5–10 mm below the joint (as recommended in the operation guidelines) should not be performed [12]. Another uncontrollable risk factor for occurrence of a cut-through may be a repeated fall [12].

Total hip arthroplasty has been recommended previously as the only valid option to salvage cut-through of helical blades after fixation of trochanteric fractures with the PFN-A [6]. However, in patients not suitable to conversion to total hip replacement, a simple blade exchange with augmentation using bone cement might be an alternative. This report presents a technical note describing how to avoid cement leakage into the hip joint through the femoral head defect following cut-through in these cases in a cadaveric setup.

Surgical technique

Surgical dissection was conducted on one human cadaver (male, 72 years old). The use of the human cadaveric material was performed according to the Guidelines of the Swiss Academy of Medical Sciences. The Donor has formally agreed the use of body parts for research purposes by signing the donation forms. The cadaver was embalmed using a technique described previously and provided by the local anatomical department [13].

The cadaver was placed in the supine position on a radiolucent table. After a lateral incision, determination of the entry point, insertion of the guide wire and reaming of the medullary canal a PFN-A was inserted

✉ J. D. Bastian
johannesbastian@gmx.de; johannes.bastian@insel.ch

[1] Department of Orthopaedic and Trauma Surgery, University of Bern, Inselspital, Freiburgstrasse 3, 3010 Bern, Switzerland

[2] Institute of Anatomy, University of Bern, Bern, Switzerland

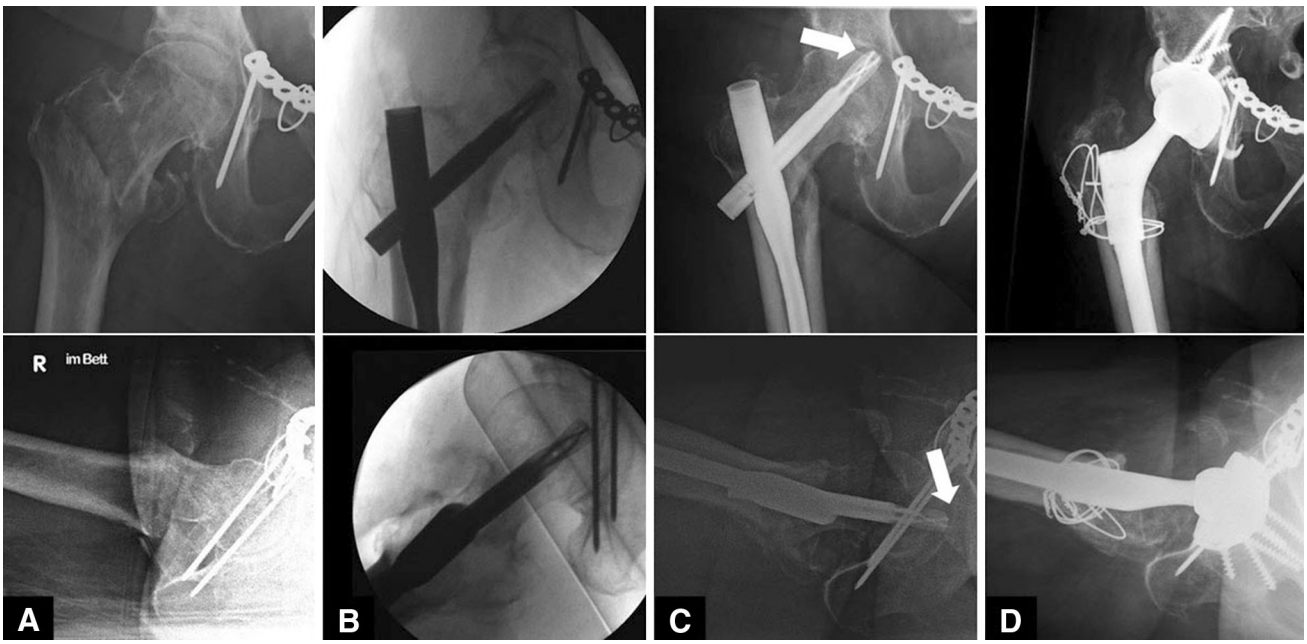

Fig. 1 **a** An 89-year-old female patient presenting with an unstable pertrochanteric fracture of the left hip (AO 31-A2) after a simple fall. **b** Intraoperative images by fluoroscan, reduction and fixation using the PFN-A. **c** Medial migration of the helical blade with perforation of the blade into the hip joint (white arrow) seven weeks after osteosynthesis. **d** Conversion to a total hip revision arthroplasty was performed a salvage procedure

(length 240 mm, diameter 10 mm, CCD angle 130°; DePuy Synthes, Johnson & Johnson AG, Zuchwil, Switzerland; Fig. 2). The guide wire (diameter: 3.2 mm) for the PFN-A blade was inserted under biplane fluoroscopic control at the correct position as previously published [7, 14]. The reamer (diameter: 11 mm) was pushed over the guide wire to ream the drill hole for the PFN-A blade. The fixation sleeve was not used to allow for reaming through the medial cortex of the femoral head to create the defect (Fig. 2a). A helical blade with excessive length (length 110 mm) was intentionally inserted to simulate the "cut-through" into the hip joint and then removed (Fig. 2b).

A medullary cement plug (PE Stühmer/Weber size 3, diameter: 13.5 mm; Zimmer GmbH, Winterthur, Switzerland), usually employed in second and third generation total hip arthroplasty techniques to improve cementing, was cut at 10 mm of length and the tip of the plug was sealed using cement. The plug was inserted into the predrilled hole for the blade up to the subchondral bone (Fig. 2c, d). Another helical blade of an appropriate length (length: 100 mm) was inserted (Fig. 2e). Cement was injected (Traumacem V+ cement, Syringe Kit, Cement Kit; DePuy Synthes, Johnson & Johnson AG, Zuchwil, Switzerland) according to the user's manual and under fluoroscopic

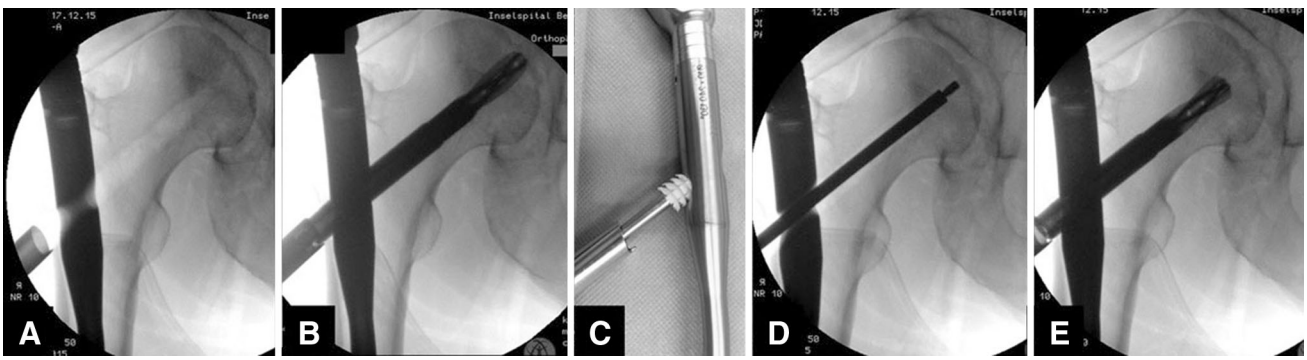

Fig. 2 Anteroposterior radiographs of a right hip joint of an anatomic specimen obtained by a fluoroscan after insertion of the PFN-A nail and **a** after drilling through the medial cortex of the femoral head, **b** insertion of a helical blade with perforation of the hip joint to simulate the defect of a medial cut-through. **c** Demonstration of the cement plug insertion through the nail of the cement plug ex vivo and **d** within the cadaver by fluoroscopic control. **e** Insertion of a helical blade of correct length and at the correct position

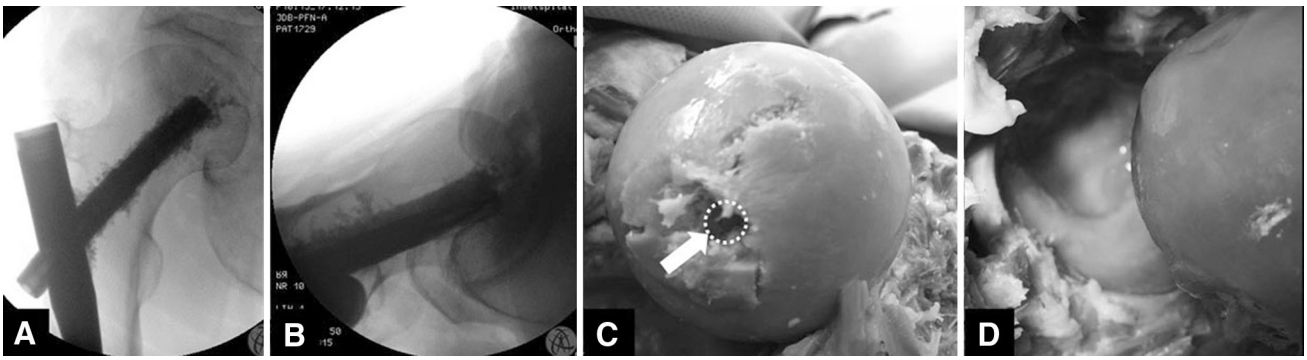

Fig. 3 **a**, **b** Fluoroscopic (anteroposterior, axial) images of the right hip in the cadaveric specimen (Fig. 2) after cement augmentation of the PFN-A. **c**, **d** Photographs after dislocation of the hip showing the defect at the medial cortex of the femoral and the cement plug. The plug is well-placed without any intraarticular protrusion and the plug locked the defect so that cement leakage to joint has neither been detected by the fluoroscan nor been noted after arthrotomy

control to avoid cement leakage. After curing of the cement an arthrotomy of the hip joint was performed to confirm that intraarticular cement leakage did not occur (Fig. 3).

Discussion

The helical-blade design in cephalomedullary devices such as the PFN-A demonstrate superiority in biomechanical tests compared to screw-design implants, decreasing the risk for cut-out. However, the total contact surface area is noted to be four times larger in screw-design implants compared to helical-blade designs. As a result, nails using a blade are at a higher risk for axial migration with medial cut-through [10].

A higher rotational stability and an enhanced pull-out resistance, especially in osteoporotic bone, was obtained by cement augmentation of the femoral head in fixation of hip fractures using the PFN-A in biomechanical testing [15]. Accordingly, cement augmentation of the PFN-A was recommended previously as a standard procedure in fixation of peritrochanteric fractures (AO 31) in osteoporotic bone to avoid failures needing a reoperation, e.g., due to cut-through of the blade [1].

Cement augmentation may further compensate in revision surgery cases such as re-nailing for peri-implant fractures at the femoral shaft, nail breakage, loosening or dislocation of the blade, non-union, near cut-out following malpositioning or lateral protrusion of the head–neck element of the implant in destroyed cancellous bone stock due to blade removal [16, 17]. Furthermore, the integrity of the medial cortex may be injured (e.g., due to perforation of the joint during drilling), however, cement leakage into the hip joint has to be strictly avoided.

In contrast to the idea of hip-preserving surgery, hip arthroplasty was recommended recently not only as a valid salvage procedure in cases with an obvious defect of the medial cortex due to a "cut-through" of the helical blade [6], but also as a primary surgical treatment for unstable peritrochanteric fractures [18]. However, nonunion of the greater trochanter occurred and a displaced greater trochanter fragment was associated with poor functional outcome [18, 19]. Additionally, in low demand patients with poor medical conditions or with an infected intramedullary nail, extensive revision surgery or conversion to a total hip replacement might be not reasonable [6, 12].

As a result, in specific cases, the surgeon should be enabled to perform a blade exchange with cement augmentation of the femoral head, even when a medial cortical defect is present (e.g., as confirmed by a positive "leakage test" [16] with contrast fluid being administered cephalomedullary and its leakage being noticed under fluoroscopic control into the joint or being obvious in cases with a cut-through of the helical blade).

Whenever management of failed cephalomedullary nailing aims for blade exchange with subsequent cement augmentation in specific cases (e.g., poor medical condition of the patient, low demand) with an intact articular cartilage but a positive leakage test, the medial cortical defect should be closed easily and reliably.

A limitation of this report may be found in the use of only one male cadaver without obvious osteoporosis or a defect void within the femoral head as the flow of the cement did not present the typical distribution pattern alike a "cloud". However, highly viscous cement is supposed to fill sites of the lowest resistance first so that the cement plug provided even a higher resistance to the injected cement than the normal cancellous bone within the femoral head in this specimen. Therefore, the cement plug should prevent intraarticular cement leakage in cases with a cephalomedullary defects following osteoporosis and/or removal or migration of the blade even more.

In conclusion, cement leakage into the hip joint was prevented by the presented technique with a standard cement plug during PFN-A cement augmentation closing the defect.

Acknowledgments We thank Paul Rodham, Newcastle, UK for his linguistic help in the preparation of this manuscript. We thank Nane Boemke, Head Preparator, Institute of Anatomy, University of Bern for her technical assistance. We thank Martin Stähli, Zimmer GmbH, for providing the medullary cement plug and Hans Gerber, DePuy Synthes, Johnson & Johnson AG, for allocating the PFN-A set.

Compliance with ethical standards

Conflict of interest None.

References

1. Kammerlander C, Doshi H, Gebhard F, Scola A, Meier C, Linhart W, Garcia-Alonso M, Nistal J, Blauth M (2014) Long-term results of the augmented PFNA: a prospective multicenter trial. Arch Orthop Trauma Surg 134:343–349
2. Liu Y, Tao R, Liu F, Wang Y, Zhou Z, Cao Y, Wang H (2010) Mid-term outcomes after intramedullary fixation of peritrochanteric femoral fractures using the new proximal femoral nail antirotation (PFNA). Injury 41:810–817
3. Mereddy P, Kamath S, Ramakrishnan M, Malik H, Donnachie N (2009) The AO/ASIF proximal femoral nail antirotation (PFNA): a new design for the treatment of unstable proximal femoral fractures. Injury 40:428–432
4. Simmermacher RK, Ljungqvist J, Bail H, Hockertz T, Vochteloo AJ, Ochs U, Werken C (2008) The new proximal femoral nail antirotation (PFNA) in daily practice: results of a multicentre clinical study. Injury 39:932–939
5. Frei HC, Hotz T, Cadosch D, Rudin M, Kach K (2012) Central head perforation, or "cut through," caused by the helical blade of the proximal femoral nail antirotation. J Orthop Trauma 26:e102–e107
6. Brunner A, Buttler M, Lehmann U, Frei HC, Kratter R, Di LM, Scola A, Sermon A, Attal R (2015) What is the optimal salvage procedure for cut-out after surgical fixation of trochanteric fractures with the PFNA or TFN?: a multicentre study. Injury 47(2):432–438
7. Nikoloski AN, Osbrough AL, Yates PJ (2013) Should the tip-apex distance (TAD) rule be modified for the proximal femoral nail antirotation (PFNA)? A retrospective study. J Orthop Surg Res 8:35
8. Gavaskar AS, Subramanian M, Tummala NC (2012) Results of proximal femur nail antirotation for low velocity trochanteric fractures in elderly. Indian J Orthop 46:556–560
9. Gardner MJ, Briggs SM, Kopjar B, Helfet DL, Lorich DG (2007) Radiographic outcomes of intertrochanteric hip fractures treated with the trochanteric fixation nail. Injury 38:1189–1196
10. Born CT, Karich B, Bauer C, von Oldenburg G, Augat P (2011) Hip screw migration testing: first results for hip screws and helical blades utilizing a new oscillating test method. J Orthop Res 29:760–766
11. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM (1995) The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. J Bone Joint Surg Am 77:1058–1064
12. Brunner A, Jockel JA, Babst R (2008) The PFNA proximal femur nail in treatment of unstable proximal femur fractures-3 cases of postoperative perforation of the helical blade into the hip joint. J Orthop Trauma 22:731–736
13. Jores L (1913) Über eine verbesserte Methode der Konservierung anatomischer Präparate. Münch med Wschr 60:976
14. Hwang JH, Garg AK, Oh JK, Oh CW, Lee SJ, Myung-Rae C, Kim MK, Kim H (2012) A biomechanical evaluation of proximal femoral nail antirotation with respect to helical blade position in femoral head: a cadaveric study. Indian J Orthop 46:627–632
15. Erhart S, Schmoelz W, Blauth M, Lenich A (2011) Biomechanical effect of bone cement augmentation on rotational stability and pull-out strength of the Proximal Femur Nail Antirotation. Injury 42:1322–1327
16. Scola A, Gebhard F, Dehner C, Roderer G (2014) The PFNA(R) Augmented in Revision Surgery of Proximal Femur Fractures. Open Orthop J 8:232–236
17. Erhart S, Kammerlander C, El-Attal R, Schmoelz W (2012) Is augmentation a possible salvage procedure after lateral migration of the proximal femur nail antirotation? Arch Orthop Trauma Surg 132:1577–1581
18. Fichman SG, Makinen TJ, Safir O, Vincent A, Lozano B, Kashigar A, Kuzyk PR (2016) Arthroplasty for unstable pertrochanteric hip fractures may offer a lower re-operation rate as compared to cephalomedullary nailing. Int Orthop 40:15–20
19. Studer P, Suhm N, Wang Q, Rosenthal R, Saleh HA, Jakob M (2015) Displaced trochanteric fragments lead to poor functional outcome in pertrochanteric fractures treated by cephalomedullary nails. Injury 46:2384–2388